

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application:

LISTING OF CLAIMS:

1. (Currently Amended) A method for optimal multimedia content delivery over networks from a server to one or more clients, comprising:

delineating a state variable that represents a data rate for delivery of multimedia content having a fixed duration and to each client, wherein an initial data rate ~~to one or more clients~~ is equal to or greater than a minimum flow rate, and wherein the minimum flow rate ensures that all required content will be available to each client when needed, and a subsequent data rate, which is equal to or less than a real-time rate of play back of the multimedia content;

delineating a set of conditions which represent time-varying constraints on the data rate of said multimedia content said conditions including:

- (1) the total data rate for all clients does not exceed the maximum throughput of the server or network, whichever is least;
- (2) the data rate from server to client does not exceed the maximum data rate for the client;
- (3) the data rate of the client will never overflow a client buffer;
- (4) the server will never underflow; and
- (5) the data rate from the server will never be less than the client's minimum data rate, and wherein the minimum data rate ~~which~~ is a non-increasing function of time obtained by dividing the content not yet delivered by the remaining play time;

delineating a cost function which represents the value of a proposed solution;

performing periodic computations in compliance with conditions (1) - (5) to obtain a state value that maximizes said cost function; and

periodically adjusting the data rate to each client to maintain an optimal solution over a given period of time.

2. (Previously Presented) A method as in claim 1, wherein said conditions further include

(6) the current maximum client data rate is given by the minimum of:
the stored initial maximum client data rate;
the data rate required to fill the remaining client buffer during the current of said periodic computations;
the data rate required to complete the delivery of said multimedia content;
the client data rate never exceeds said current maximum client data rate; and

whereby said current maximum client data rate is periodically recomputed to maintain an optimal solution over a given period of time.

3. (Previously Presented) A method as in claim 2, wherein:
said cost function represents maximal throughput and is given by the sum of said client data rates for all active clients.

4. (Previously Presented) A method as in claim 2, wherein:
said cost function represents maximal charge and is given by the sum for all active clients of said client data rates times the client's cost of service.

5. (Previously Presented) A method as in claim 3 for bandwidth allocation for delivery of multimedia data from server to one or more clients over a network, comprising the steps of:
determining the maximum flow rate and minimum flow rate for each client;
determining the flow rate range for each client as given by the difference between said maximum flow rate and said minimum flow rate;
initializing current flow rate for each client as said minimum flow rate and summing said flow rate into total server flow rate; and
allocating remaining server bandwidth to remaining clients until they each saturate or no bandwidth remains.

6. (Previously Presented) A method as in claim 5 wherein said step of allocating remaining server bandwidth to remaining clients comprising:

- sorting the list of clients according to said flow rate range;
- determining equally-allocated remaining server bandwidth if allocated evenly to all remaining unprocessed clients;
- determining the range of remaining client bandwidth as given by the difference between said maximum flow rate and said minimum flow rate; [[and]]
- determining saturation by comparing said equally-allocated remaining server bandwidth and said range of remaining client bandwidth, and allocating the lesser of these two amounts to each remaining client flow rate; and
- whereby allocating flow to remaining clients based upon the sorted client range flow rates and determining allocation of remaining server bandwidth based upon a comparison of saturation of server versus saturation of each client maximizes allocation of total bandwidth for maximal flow rate to maximum number of clients.

7. (Previously Presented) A method as in claim 4 for bandwidth allocation for delivery of multimedia data from server to one or more clients over a network, comprising the steps of:

- determining the maximum flow rate and minimum flow rate for each client;
- determining the flow rate range for each client as given by the difference between said maximum flow rate and said minimum flow rate;
- sorting the list of clients according to said flow rate range;
- initializing current flow rate for each client as said minimum flow rate and summing said flow rate into total server flow rate; and
- allocating remaining server bandwidth to remaining clients such that lower paying clients receive bandwidth only if higher paying ones are saturated.

8. (Previously Presented) A method as in claim 7 wherein said step of allocating remaining server bandwidth to remaining clients comprises the steps of:

- for each remaining unprocessed client:
 - determining equally-allocated remaining server bandwidth if allocated evenly to all remaining unprocessed clients;
 - determining the range of remaining client bandwidth as given by the difference between said maximum flow rate and said minimum flow rate;

determining saturation by comparing said equally-allocated remaining server bandwidth and said range of remaining client bandwidth, and allocating the lesser of these two amounts to each remaining client flow rate; and whereby allocating flow to remaining clients based upon the sorted client range flow rates and determining allocation of remaining server bandwidth based upon a comparison of saturation of server versus saturation of each client maximizes allocation of total bandwidth for maximal flow rate to maximum number of clients.

9. (Currently Amended) A method for connection acceptance control for delivery of multimedia data from server to one or more clients over a network, comprising the steps of:

determining server swing capacity given by the difference between the total server bandwidth and the sum of the minimum flow rates of all currently-connected clients receiving multimedia data having a fixed duration, wherein the minimum flow rate for each client is expressed as a non-increasing function of time obtained by dividing data not yet delivered by remaining play time, and wherein the minimum flow rate ensures that all required data will be available to each client when needed; and

allocating server bandwidth for each prospective client which will fit without server bandwidth saturation, as determined by comparing an average data play rate of each prospective client with the remaining bandwidth, represented by said server swing capacity, available to the server[.];

~~wherein the minimum flow rate for each client is expressed as a non-increasing function of time obtained by dividing content not yet delivered by remaining play time, and wherein the minimum flow rate ensures that all required content will be available to each client when needed.~~

10. (Original) A method as in claim 9 wherein said remaining bandwidth available to the server is given by said server swing capacity.

11. (Previously Presented) A method as in claim 10 wherein said remaining bandwidth available to the server is give by said server swing capacity less a server flow safety margin, thereby allowing server capacity to be

subsequently lowered by up to the safety margin without requiring load shedding, and without affecting client sessions in process.

12. (Previously Presented) A method as in claim 9 wherein said step of allocating server bandwidth for each prospective client which will fit without server bandwidth saturation comprises:

allocating server bandwidth to each prospective client sequentially until a prospective client is located in which said average data play rate exceeds said server swing capacity.

13. (Previously Presented) A method as in claim 9 wherein said step of allocating server bandwidth for each client which will fit without server bandwidth saturation comprises:

allocating server bandwidth to each prospective client sequentially for each client which can be activated without server bandwidth saturation.

14. (Currently Amended) A method for bandwidth allocation for delivery of multimedia data from a server to one or more clients over a network, the method comprising:

storing multimedia data on at least one server, the multimedia data having a fixed duration;

delivering the multimedia data from the at least one server to at least one client device upon demand of the at least one client by way of a network having a defined bandwidth, and wherein the multimedia data is available for playback upon client request;

storing a sequence of data representing scheduled bandwidth changes for the at least one server;

determining a ~~the~~ maximum flow rate and a minimum flow rate for each of the one or more clients ~~client~~ at the present time, the determination of the minimum flow rate being based on a non-increasing function of time obtained by dividing multimedia data ~~content~~ not yet delivered by remaining play time, and wherein the minimum allowed flow rate ensures that all required multimedia data ~~content~~ will be available to each client when needed;

determining the flow rate range for each client as given by the difference between said maximum flow rate and said minimum flow rate;
sorting the list of clients according to said flow rate range;
initializing current flow rate for each client as said minimum flow rate and summing said flow rate into total server flow rate; and
allocating remaining server bandwidth to remaining clients.

15. (Previously Presented) The method of Claim 1, wherein the data rate ensures that all required content will be available to each client when needed.

16. (New) The method of Claim 1, further comprising ceasing delivery of the multimedia content to the at least one client when the content not yet delivered is equal to zero.

17. (New) The method of Claim 1, further comprising accepting a new client by:
determining an admission capacity of the bandwidth;
admitting a prospective client if the clients minimum allowed value of the state variable is less than the admission capacity; and
wherein a client admitted for service is guaranteed to have sufficient content flow over the entire session.

18. (New) The method of Claim 14, further comprising ceasing delivery of the multimedia data to the at least one client when the data not yet delivered is equal to zero.

19. (New) The method of Claim 14, further comprising accepting a new client by:
determining an admission capacity of the bandwidth;
admitting a prospective client if the remaining clients minimum allowed value of the state variable is less than the admission capacity; and
wherein a new client admitted for service is guaranteed to have sufficient data flow over the entire session.